

Defense Forensic Science Center

Objective Classification of Fingerprint Image Complexity



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NIST International Symposium on Forensic Science Error Management



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Fingerprint Clarity . . . Risk of error?



Is the risk of error uniform across all impressions?

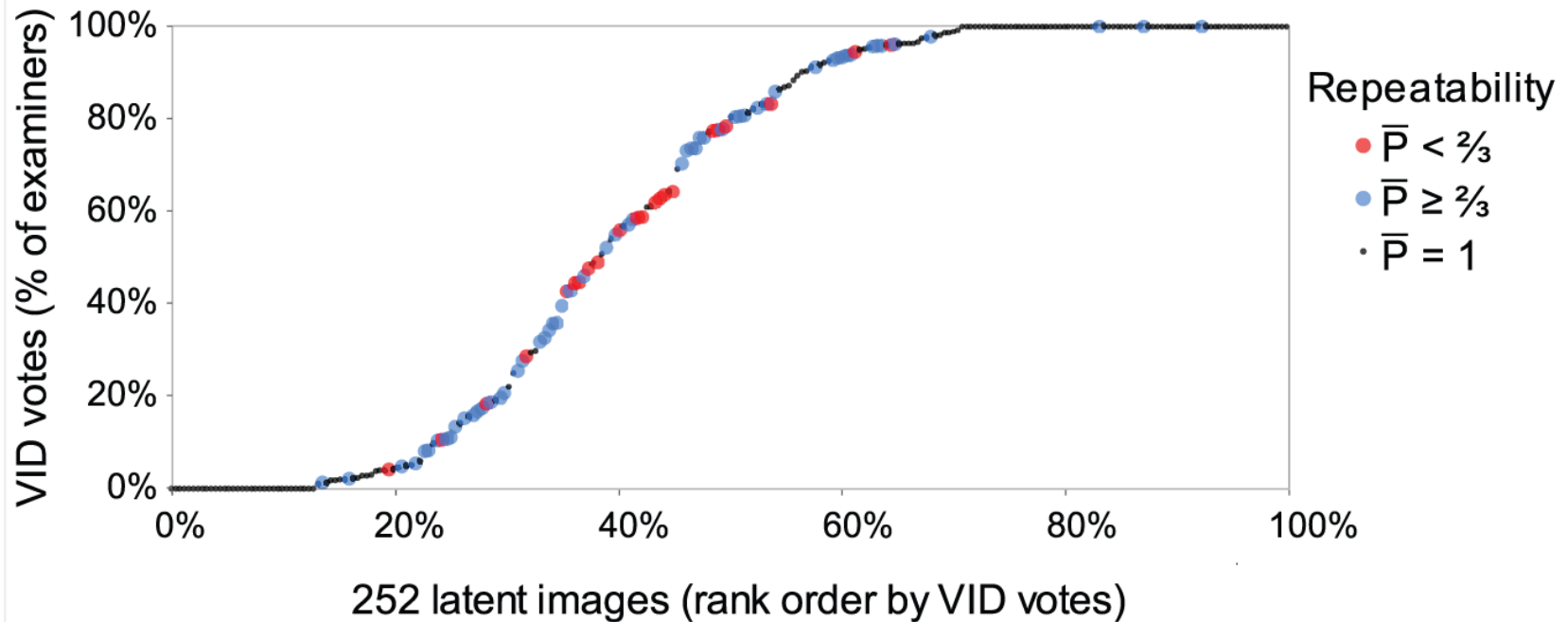
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Fingerprint Clarity . . . Risk of error?



Ulery B., Hicklin R., Buscaglia J., and Roberts M. Repeatability and Reproducibility of Decisions by Latent Fingerprint Examiners, 2012, PLoS ONE

**Reproducibility & Repeatability are
not uniformly distributed**

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Fingerprint Clarity . . . Risk of error?

	Individualization		Exclusion	
	Repeated	Reproduced	Repeated	Reproduced
Obvious/Easy/Medium	92%	85%	88%	77%
Difficult/Very Difficult	69%	55%	70%	50%

Ulery B., Hicklin R., Buscaglia J., and Roberts M. Repeatability and Reproducibility of Decisions by Latent Fingerprint Examiners, 2012, PLoS ONE

Level of difficulty is a predictor for greater uncertainty and less reproducibility/repeatability in reported decisions



Objectives

- 1. Quantify the clarity of fingerprint information**
- 2. Correlate clarity with examiner performance metrics to generate difficulty classification scheme**
- 3. Define quantitative parameters for decision making**
- 4. Prioritize QA/QC resources for prints in of a certain classification**
- 5. Utilize classification scheme to monitor conformance of analysts' visual detection and interpretation systems within predefined parameters**



Literature Review & Other Approaches



1. Ulery B., Hicklin R., Buscaglia J., and Roberts M. Repeatability and Reproducibility of Decisions by Latent Fingerprint Examiners, 2012, PLoS ONE
2. Kellman et al. Forensic Comparison and Matching of Fingerprints: Using Quantitative Image Measures for Estimating Error Rates through Understanding and Predicting Difficulty

Other approaches . . .

- *NIST (2004)*: NIST Fingerprint Image Quality (NFIQ)
- *Nill (2007)*: Image Quality of Fingerprint (IQF)
- *Yoon et al. (2013)*: Latent Fingerprint Image Quality (LFIQ)
- *Noblis (2015)*: Latent Quality Metric (LQMetric)

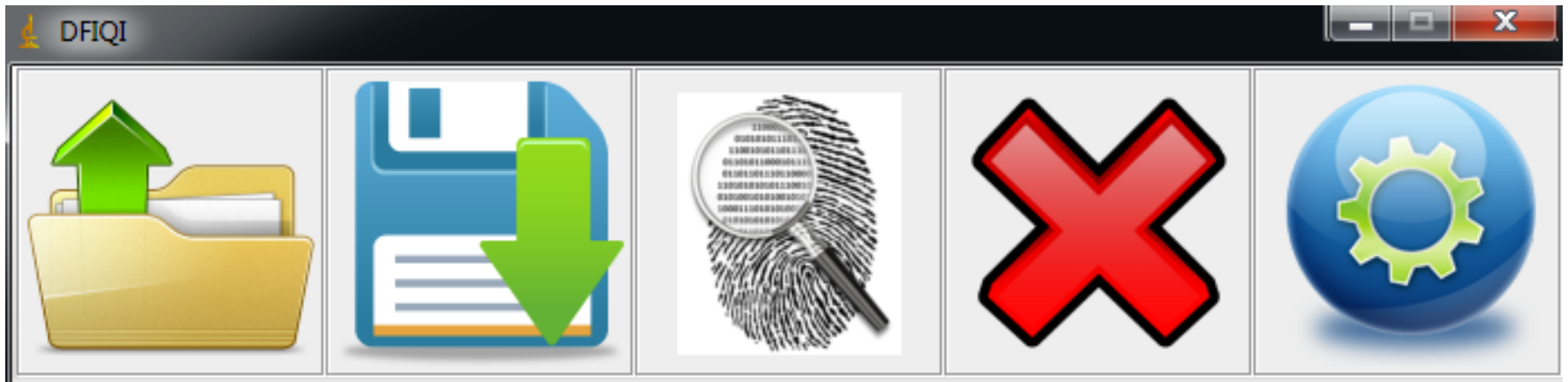


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DFIQI



Defense Fingerprint Image Quality Index (DFIQI)



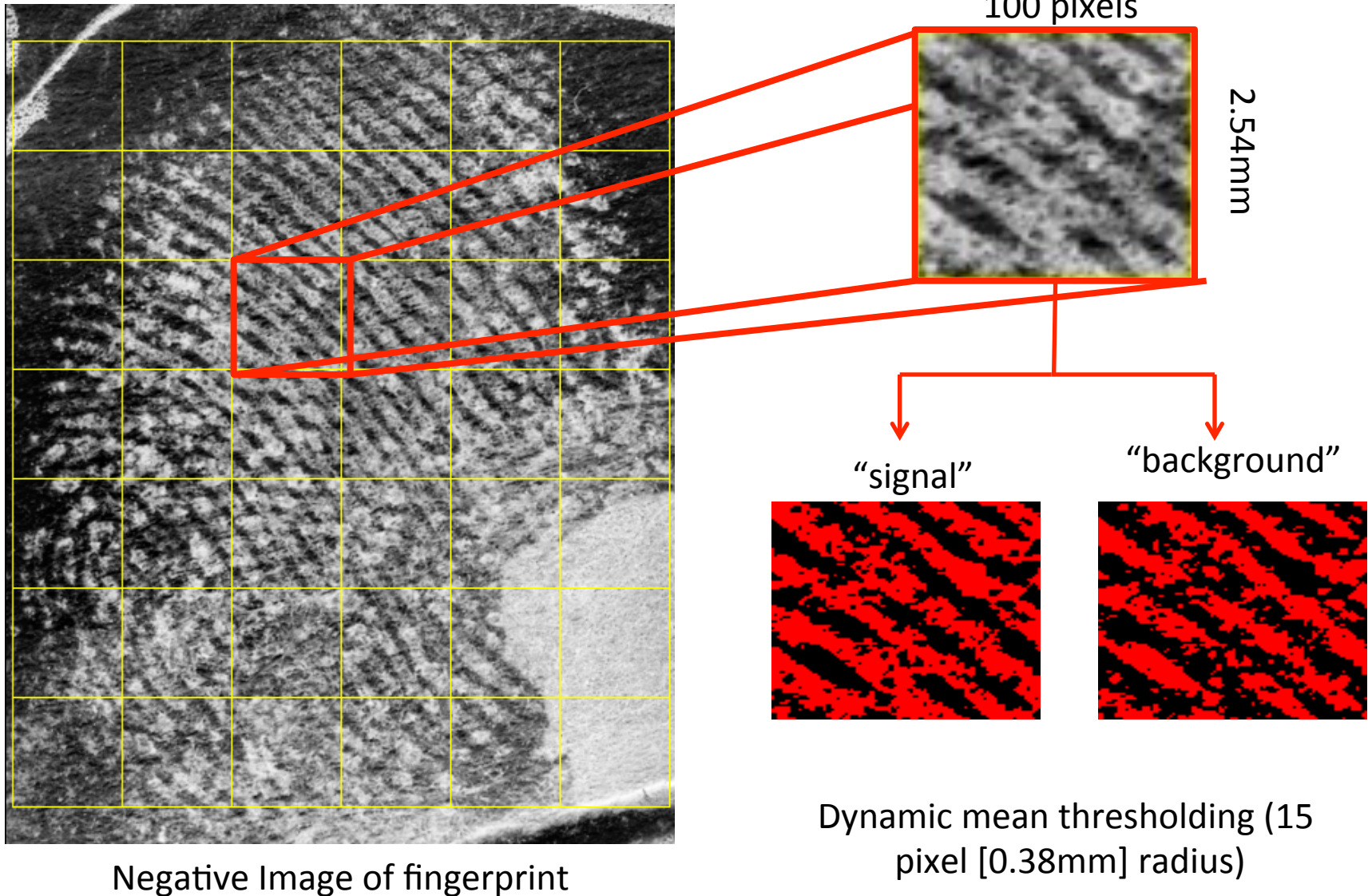
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Image is segmented and thresholded



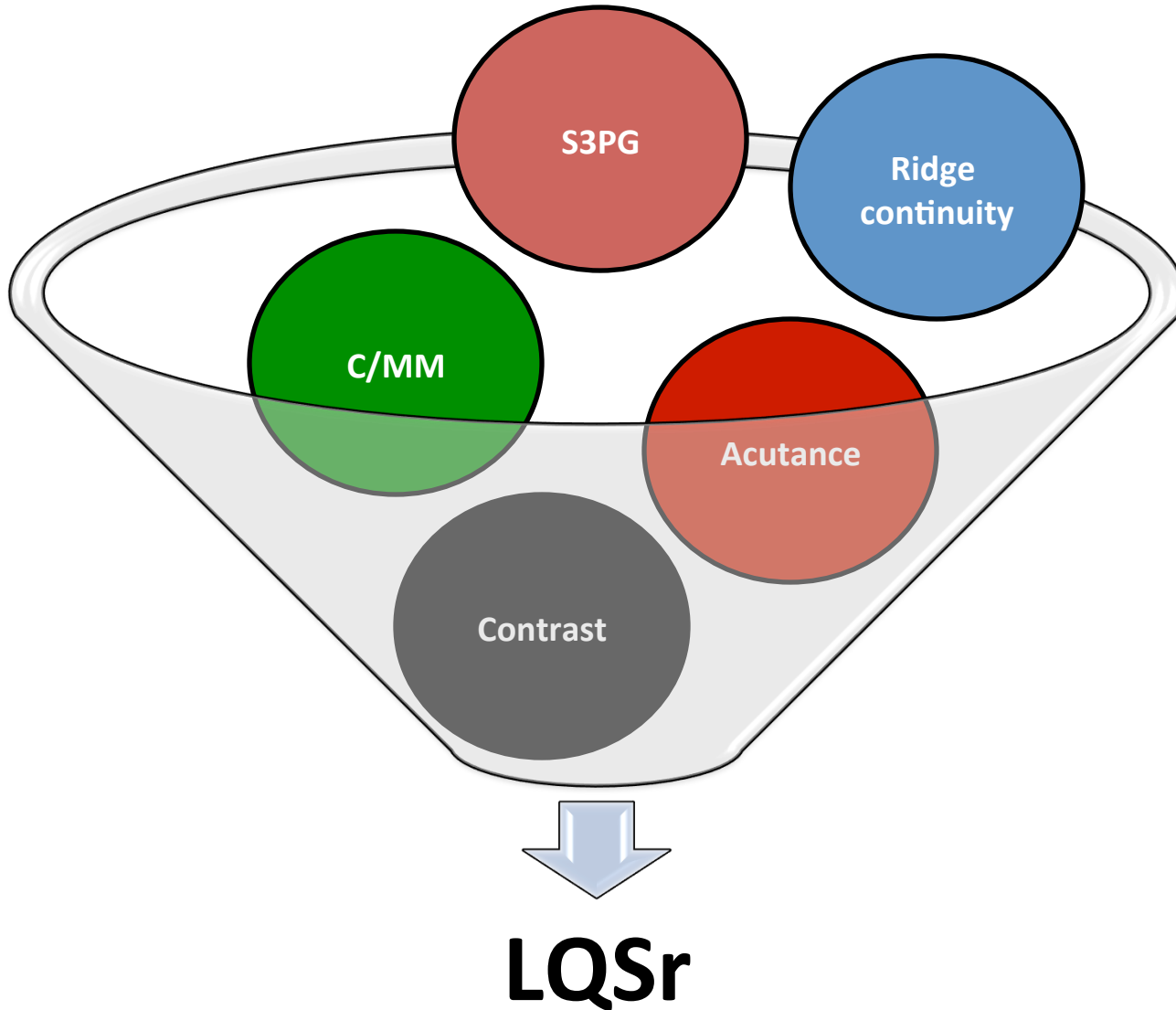
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Five variables measure clarity



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What does "Good" look like?



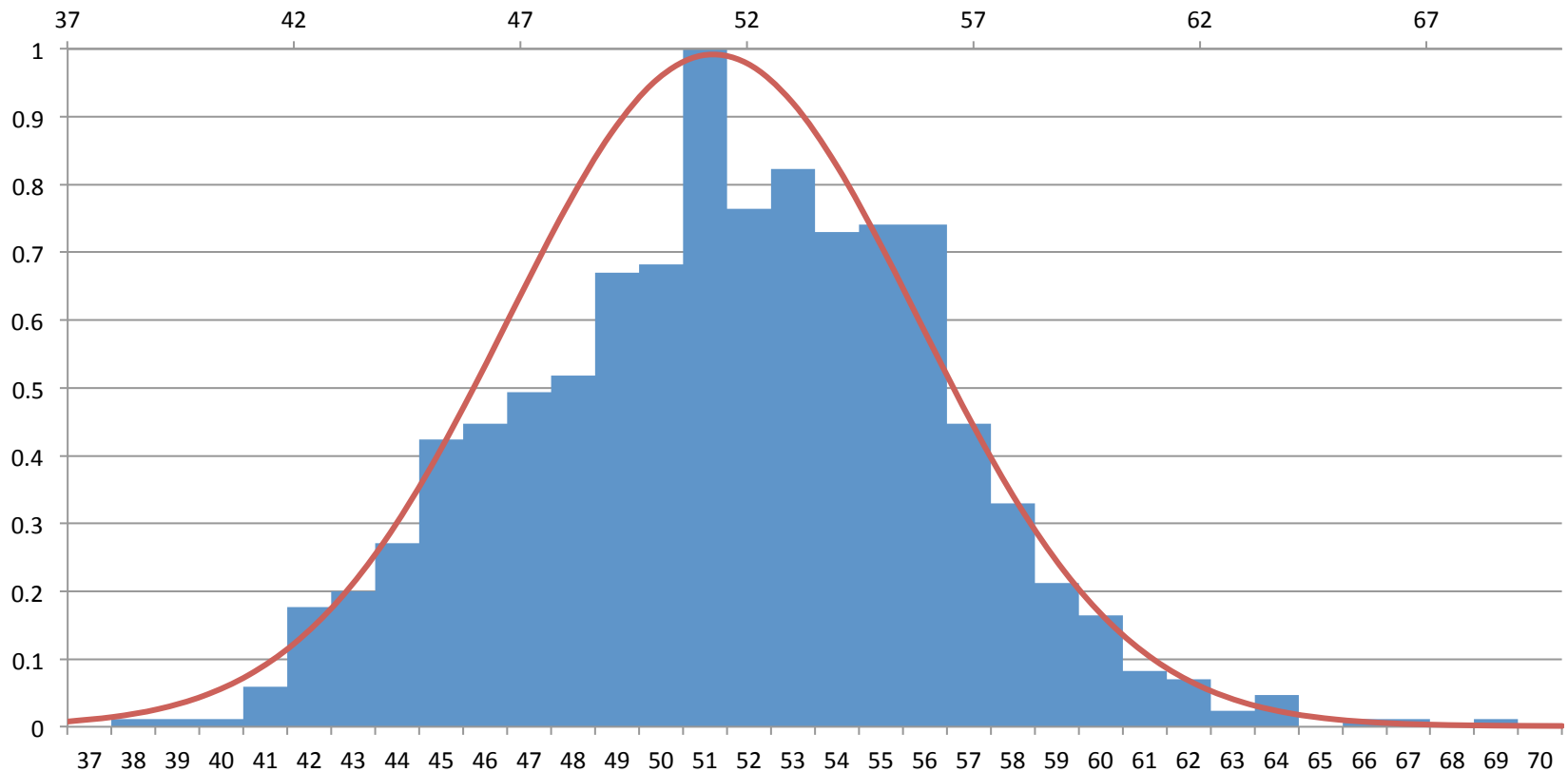


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Signal Percent Pixel Per Grid (S3PG)

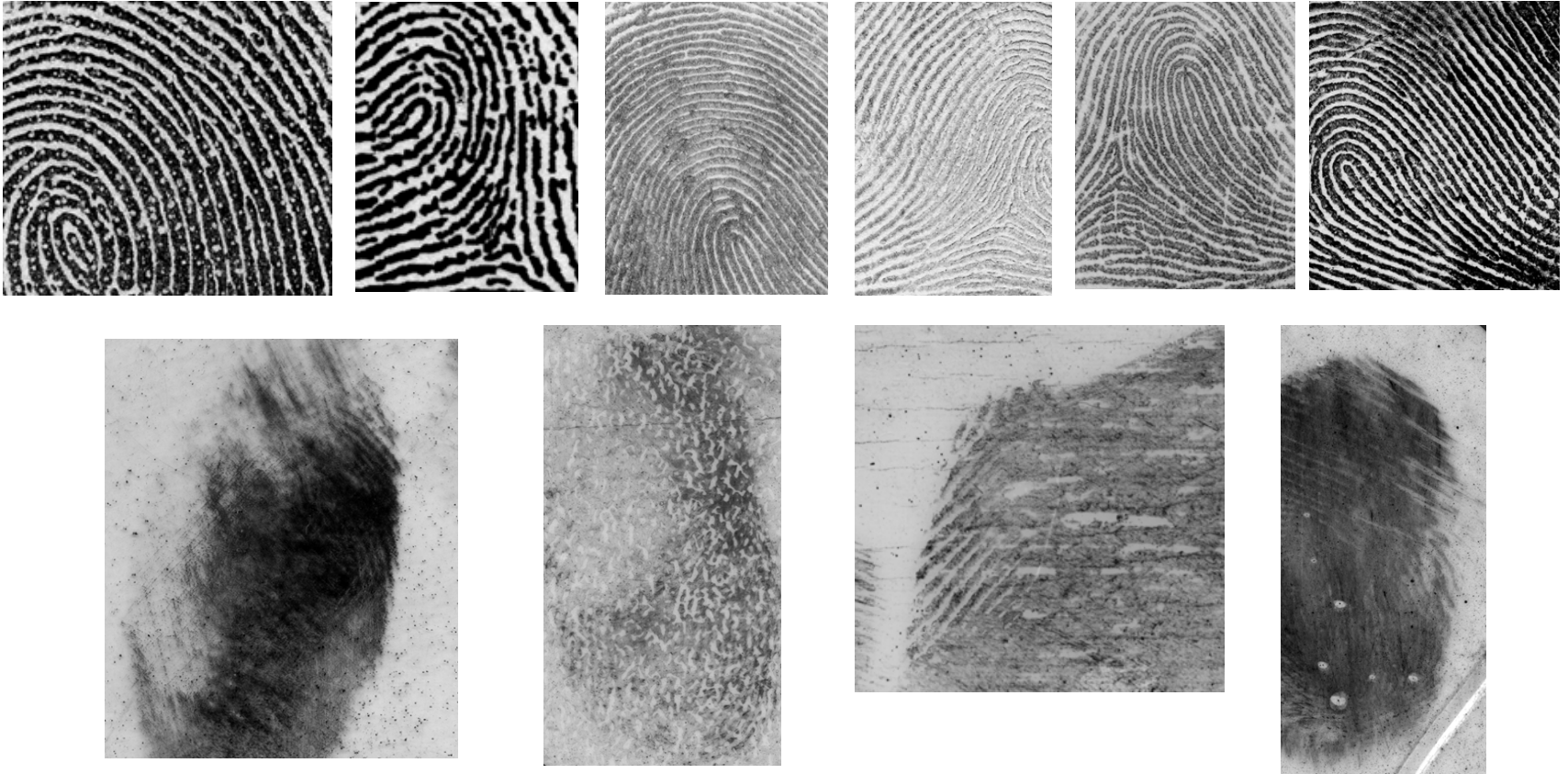
$$S3PG = 0.001003 + \left(0.991117 \times e^{-\left(\frac{(S3PG_r - 51.2606)^2}{40.878882} \right)} \right)$$



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Is LQSr any good at separating “good” vs. “bad”?



Normalized local quality score evaluated using operationally developed “Good” and “Bad” fingerprint regions

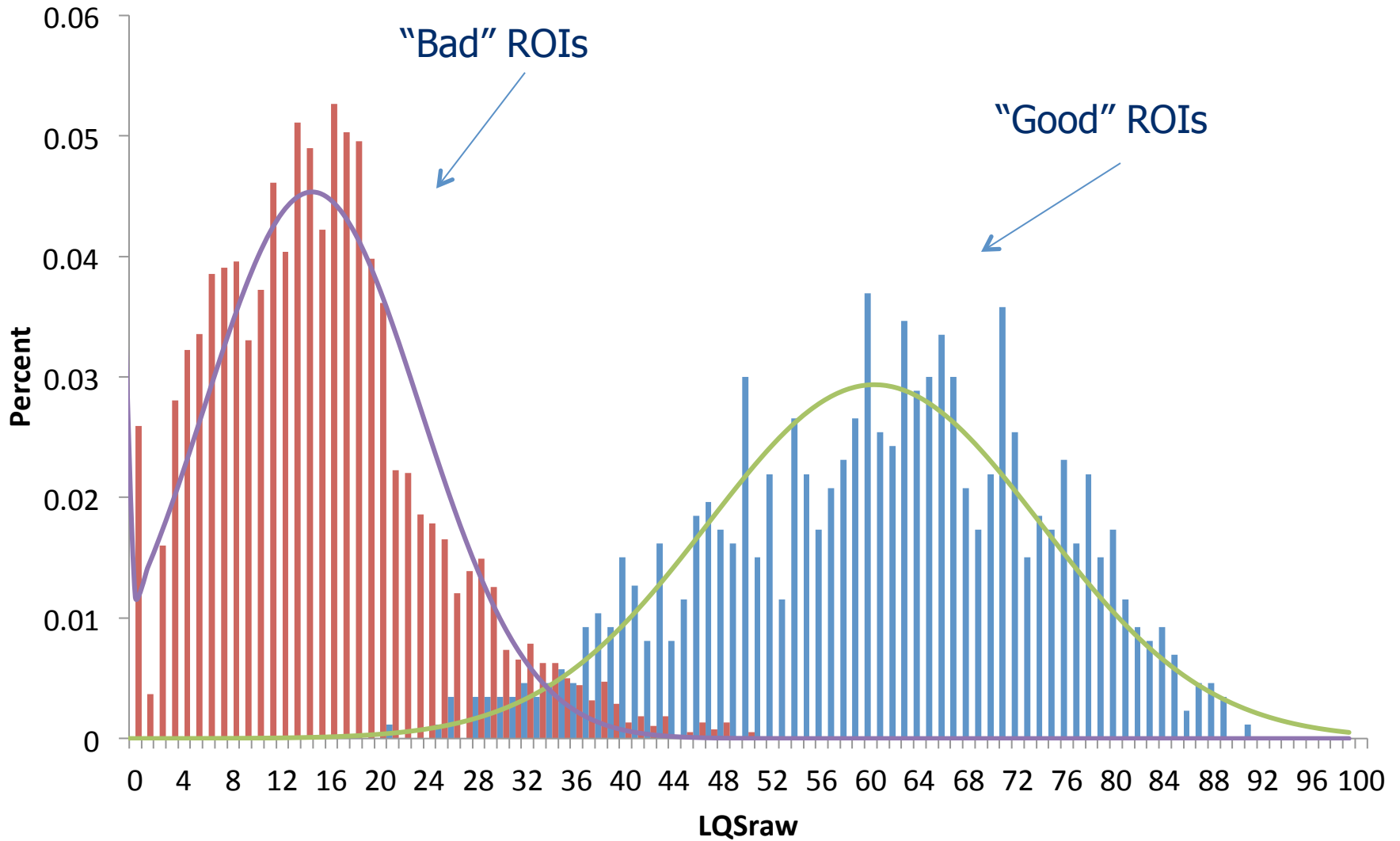
(images above are full fingerprints – regions of interest are 2.54mm x 2.54mm regions)

866 “Good” quality fingerprint ROIs and 3,699 “Bad” quality fingerprint ROIs



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LQSraw



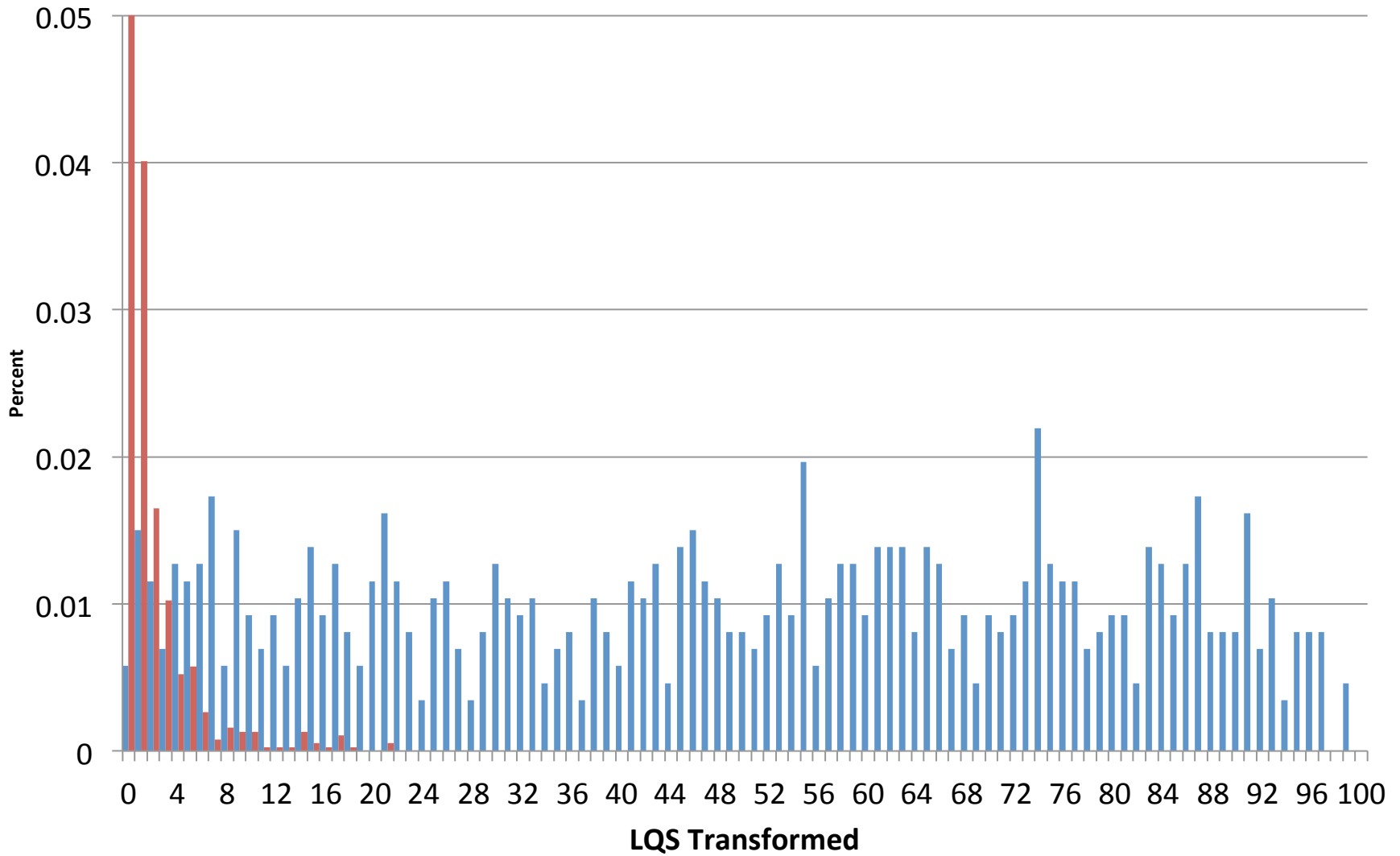
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LQS - Transformed



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GQS Calculation

GQS is the sum of LQS scores bounded by the largest contiguous area of ROIs having a LQS score >0

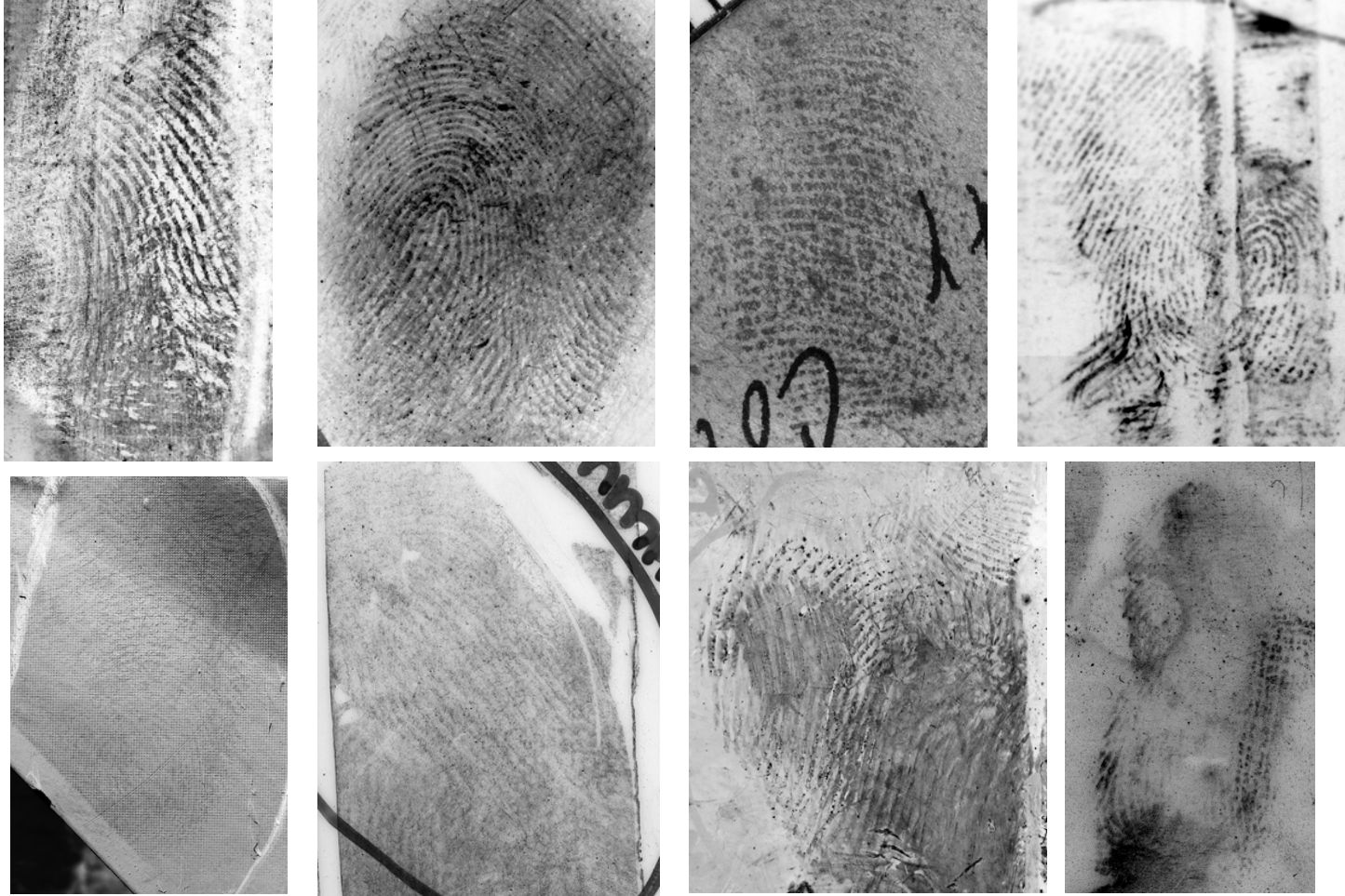
0	0	2	19	15	1
0	40	45	53	21	0
3	39	22	36	18	1
10	7	11	5	5	1
1	22	19	9	0	0
0	2	4	11	1	0
0	17	1	1	1	0

$$GQS = \sum LQS$$



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GQS Evaluation



Global Quality Score evaluation against NIST SD 27 and Operationally Derived Dataset of "suitable" and "not suitable"

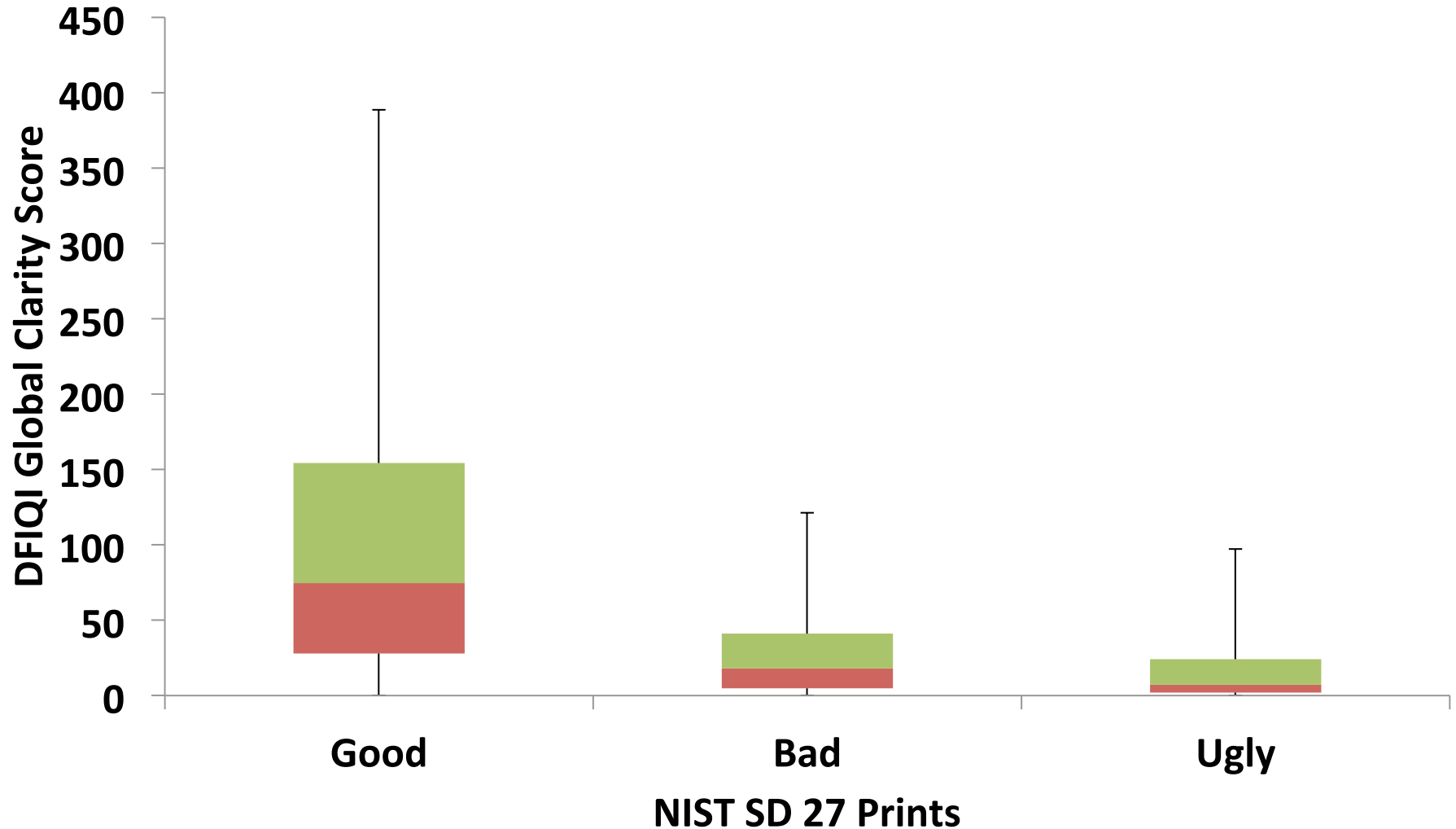
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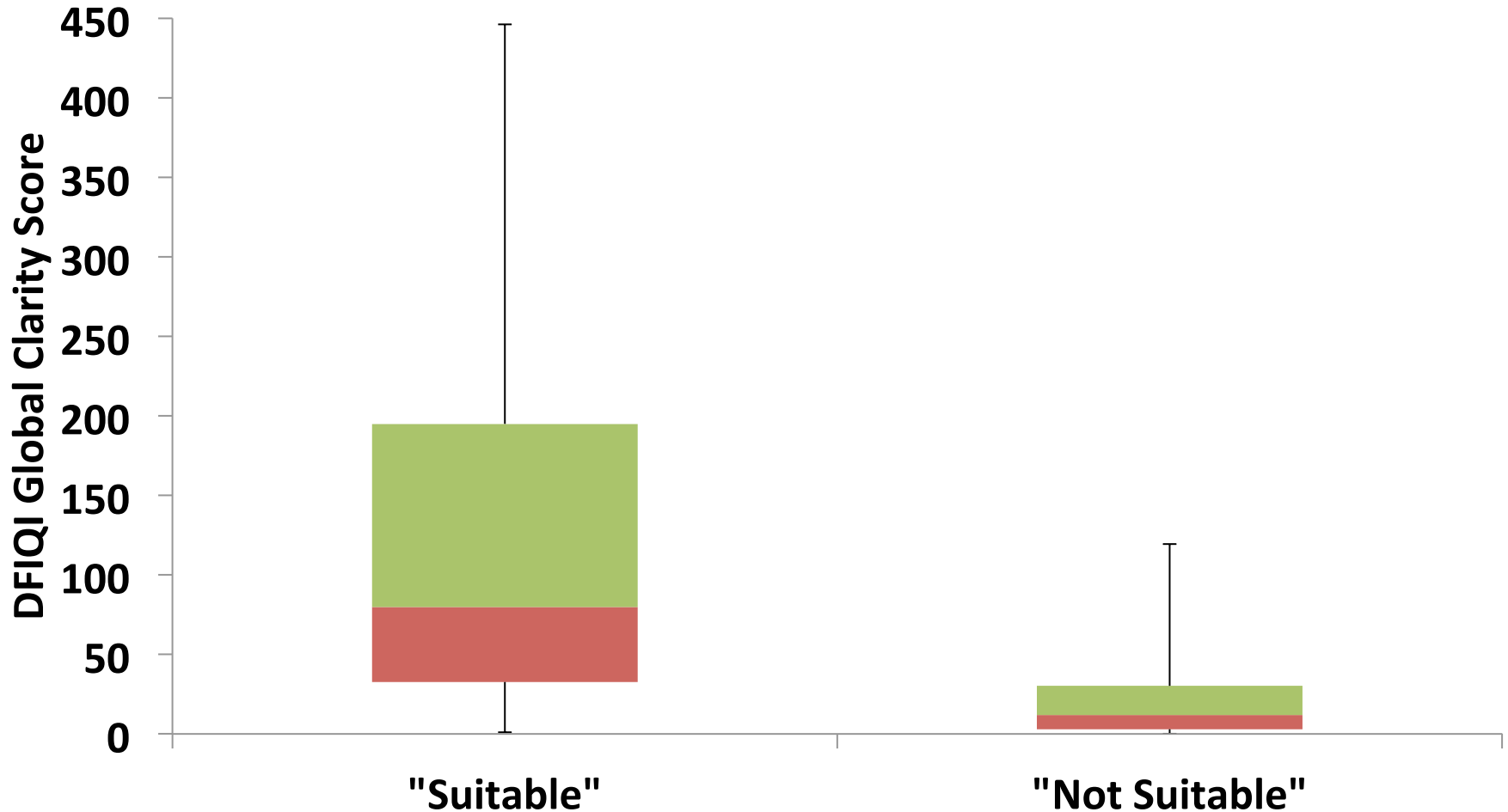
DFIQI Clarity Score vs. Subjective Assessment



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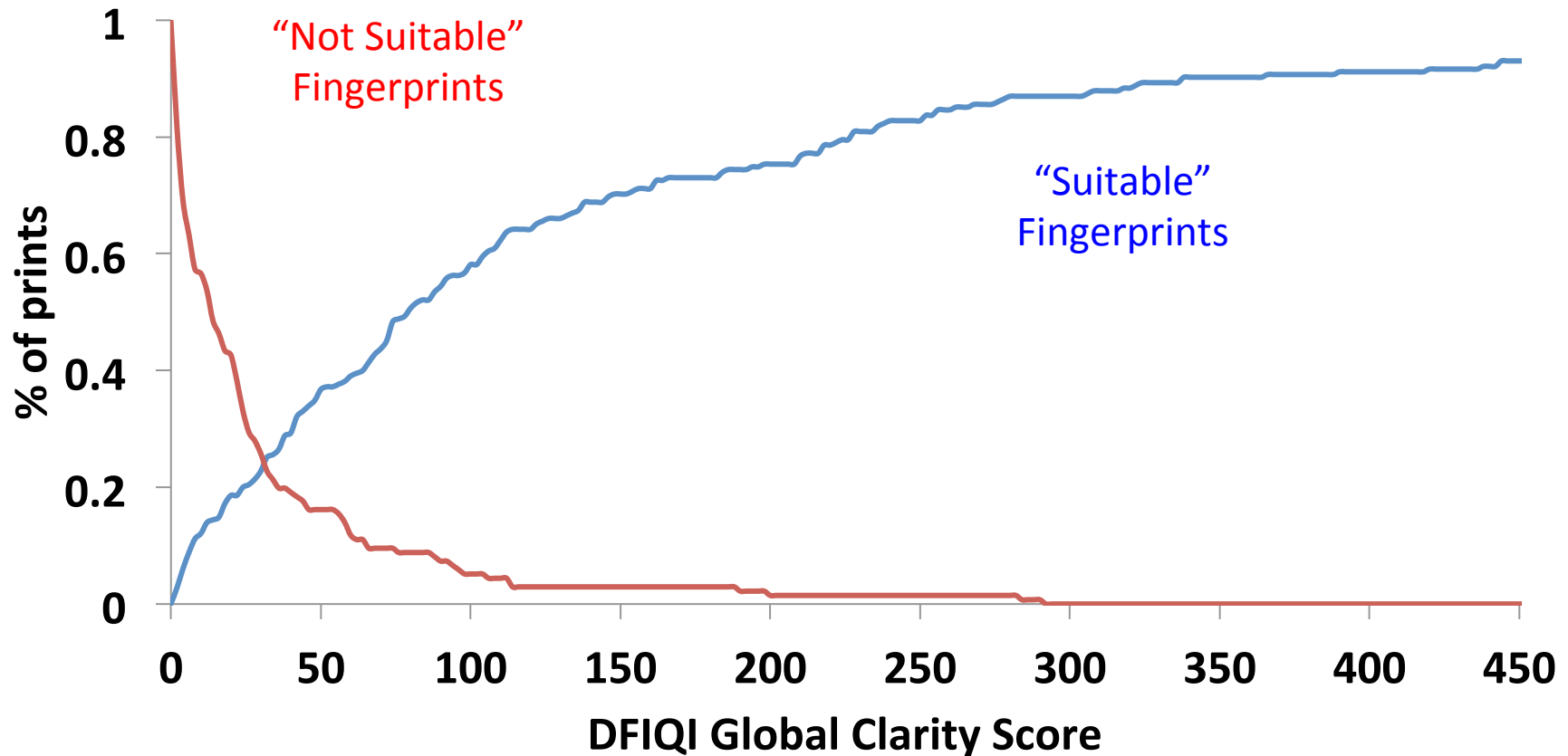
DFIQI Clarity Score vs. Subjective Assessment



215 "Suitable" and 130 "Not Suitable" prints from operation



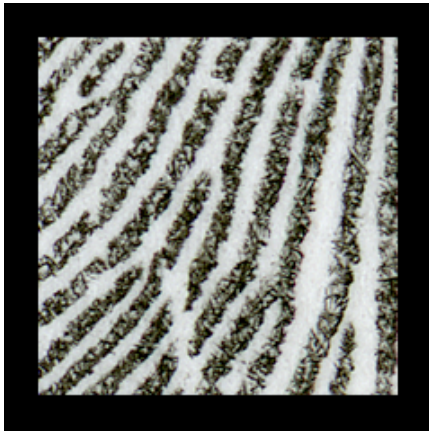
GQS Separation of "Value"



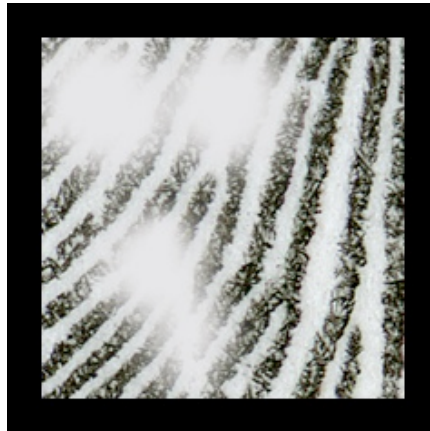
Results of normalized global quality score for operationally derived fingerprints considered "Suitable for identification" (215) and "Not suitable for identification" (130) by Latent Fingerprint Examiners



Can GQS predict "success"?



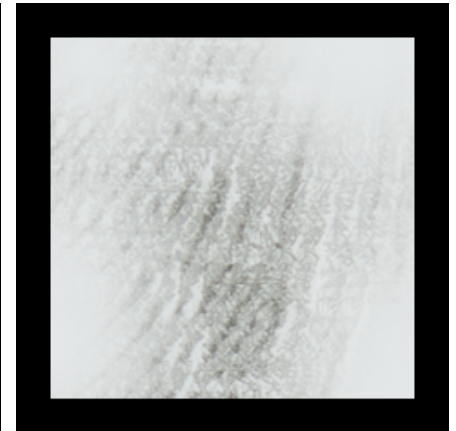
GQS: 363



GQS: 169



GQS: 3



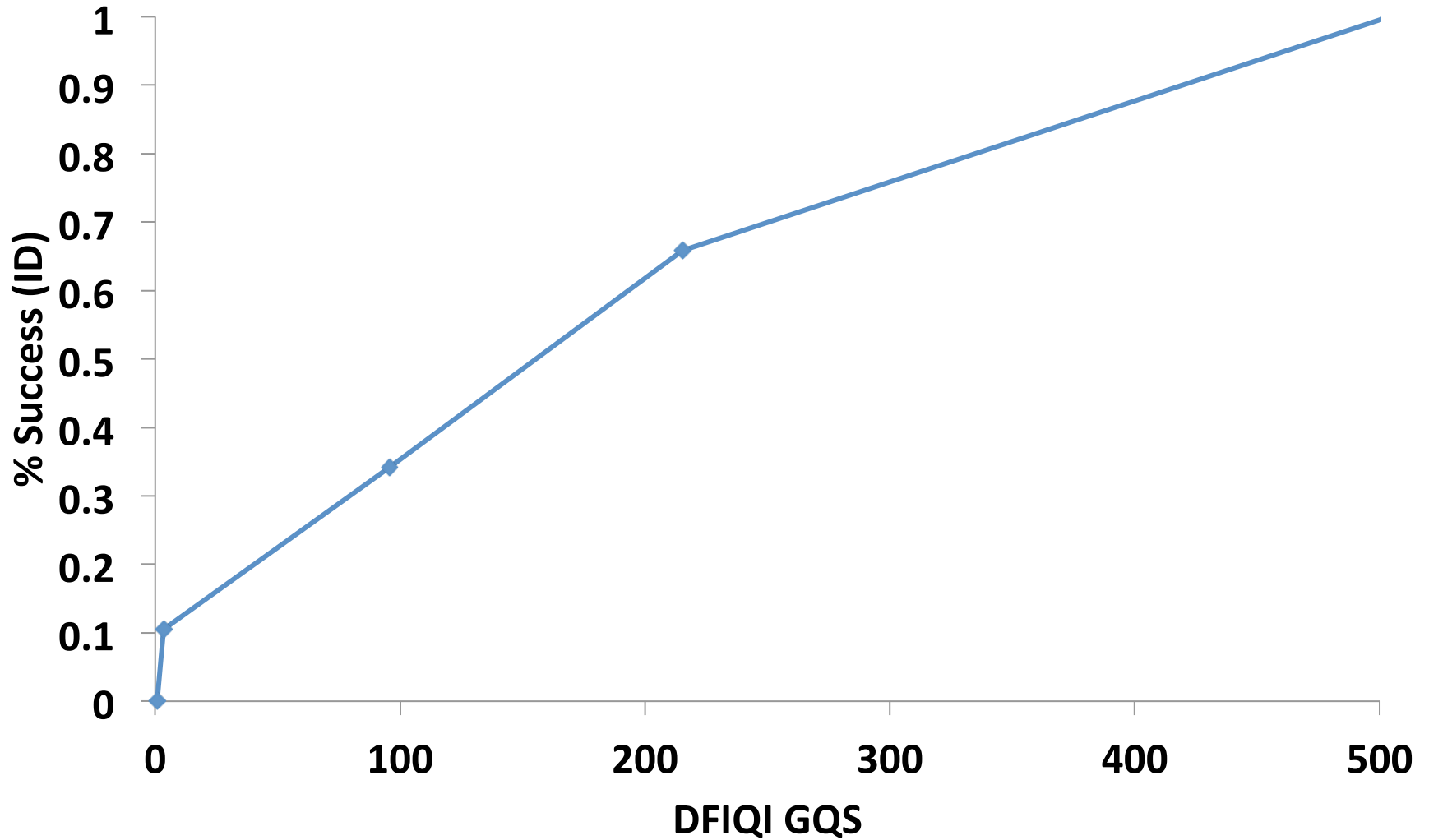
GQS: 0



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Successful ID vs. GQS



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Conclusion

Fingerprint image quality can be measured quantitatively, objectively

DFIQI or other similar software algorithms can classify the relative complexity of a fingerprint comparison a priori based on analyst performance metrics at various clarity scores

Quantitative results provide technical management an effective, transparent, and robust mechanism for error management, detection, and mitigation.

Scores may be used to define and standardize decision thresholds throughout laboratory, community



Acknowledgement

Fabian Zemp, UNIL, Lausanne, Switzerland

DFSC Fingerprint Examiners

Dr. Hari Iyer, NIST

DFSC Research Scientists – Office of the Chief Scientist, DFSC



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